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ABSTRACT

The programs in these three booklets are designed to demonstrate how the computer can be applied to the problems of many disciplines. The problems and the corresponding computer programs are, for the most part, quite simple and are designed to be "jumping-off points" for students from the high school level up. Programs include one or more from each of the following areas: mathematics (calculating, algebra, geometry, plotting), statistics, physics, chemistry, biology, ecology, social studies, electricity and electronics, business, and games (slot machine or one-armed bandit). In addition to the computer program, the source, a description of the program, a discussion of the approach used in solving it, a sample printout, and the educational benefits are listed for each problem. The language BASIC is used for all programs. (Author/JK)

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BASIC APPLICATION PROGRAMS

ED052610

INTRODUCTION

The programs contained in this book are designed to demonstrate how the computer can be applied in a meaningful way to problems of many disciplines. The problems and the corresponding programs are, for the most part, quite simple and are designed to be "jumping off points" for students from the high school level on up. Programs include one or more from each of the following areas:

Mathematics
- Calculating
- Algebra
- Geometry
- Plotting

Physics
Chemistry
Biology
Ecology
Social Studies
Economics
Business
Electricity & Electronics
Teacher Aids
Games & Recreation

All of the programs, with a very few exceptions, may be run on EduSystems 10 through 90, PDP-8 Family and PDP-11 Family computers. Very large programs will not always run on EduSystems 10 (4K PDP-8); this is noted in the program description.

EM009004-1

FOR MORE INFORMATION

For more advanced or comprehensive problems in BASIC, the following books are suggested:

Higgins, G. Albert, Jr.
The Elementary Functions: An Algorithmic Approach
Kiewit Computation Center
Dartmouth College
Hanover, New Hampshire 03755

Albrecht, R. & Finkel, L.
Math I, Math II, Business I and Social Studies I
Tecnica Education Corporation
655 Skyway Boulevard
San Carlos, California 97040

Sage, Edwin R.
Problem Solving With the Computer
Entelek, Incorporated
42 Pleasant Street
Newburyport, Massachusetts 01950

Johnson, D.C., et al
Computer Assisted Mathematics Program (CAMP) - 7 Volumes
Scott, Foresman & Company
Glenview, Illinois 60029

Coan, James S.
Basic BASIC
Hayden Book Company
New York, N.Y.

Albrecht, R., Lindberg, E., Mara, W.
Computer Methods in Mathematics
Addison-Wesley Publishing Company
Menlo Park, California 94025

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AREA: Mathematics NUMBER: NAME: DRINKR
SOURCE: Digital Equipment Corp. LANGUAGE: BASIC

DESCRIPTION: This program illustrates how the computer, used as an extended calculator, can solve the following problem:

35 persons per 1000 have high blood pressure. 80% of those with high blood pressure drink, and 60% without high blood pressure drink. Estimate the fraction of drinkers with high blood pressure.

APPROACH: This problem requires the solution of several simple equations. If we let H = the number of people with high blood pressure, then:

$$H = 35$$

And if Hl = the number of people with high blood pressure who drink, then:

$$Hl = .80 * H$$

Letting Ll - the number of people with low blood pressure who drink yields:

$$Ll = .60 * (1000 - H)$$

Now, we can solve for the number of drinkers, D:

$$D = Hl + Ll$$

Finally, the percentage of drinkers with high blood pressure is:

$$X = Hl * 100 / D$$

The program below solves the problem in a jiffy:

```
READY

 5 PRINT "PROGRAM DRINKR"
 6 PRINT
10 LET H=35
20 LET H1=.8*H
30 LET L1=.6*(1000-H)
40 LET D=H1+L1
50 LET X=H*100/D
60 PRINT X;"% DRINKERS HAVE HIGH BLOOD PRESSURE."
70 PRINT H*100/1000;"% OF ALL PEOPLE HAVE HIGH BLOOD PRESSURE."
99 END

RUN

PROGRAM DRINKR

 5.766063 % DRINKERS HAVE HIGH BLOOD PRESSURE.
 3.5 % OF ALL PEOPLE HAVE HIGH BLOOD PRESSURE.


READY
```

EDUCATIONAL BENEFITS: This type of problem can be written directly in BASIC without going through the steps above. Recognizing this type of problem readily will save lots of pencil-pushing time.

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AREA: Mathematics NUMBER: NAME: Bicycl
SOURCE: Digital Equipment Corp LANGUAGE: BASIC
DESCRIPTION: The solution to this problem illustrates how the computer can be used as a powerful calculator. The problem is:

A boy on a bicycle and a man in a car start at the same time from town A for town B, 110 miles away. They travel over the same road at 6 and 40 miles per hour respectively. When the man in the car reaches B, he will stop for 15 minutes and then start back again. How many hours will the boy on the bicycle have traveled when he meets the car on its return trip?

USAGE: Let's set up our equations first. Remember distance = rate * time or T = D/R. Letting T1 be the time the car has traveled before it starts the return trip, then:

$$T1 = \frac{110 \text{ mi}}{40 \text{ mph}} + \frac{1}{4} \text{ hr.}$$

The bicycle has traveled T1 * 6 mph at the time the car starts back. Hence the time until they meet is

$$T2 = \frac{110 - T1*6}{40 \text{ mph} + 6 \text{ mph}}$$

The total time is T1 + T2, so now we can easily write a program to solve the problem:

```
 5 PRINT "PROGRAM BICYCL"
 6 PRINT
10 LET T1=110/40+1/4
20 LET T2=(110-6*T1)/(40+6)
30 PRINT "CYCLIST HAS TRAVELED";T1+T2;"HOURS WHEN BOTH MEET."
99 END

RUN

PROGRAM BICYCL

CYCLIST HAS TRAVELED 5 HOURS WHEN BOTH MEET.
```

Not very difficult and the numbers "come out even." But they don't have to. Let's try it over a distance of 112 miles with speeds of 7.5 mph and 46 mph respectively. The computer solves this one just as easily. Can you?

```
READY

10 LET T1=112/46+1/4
20 LET T2=(112-7.5*T1)/(46+7.5)

RUN

PROGRAM BICYCL

CYCLIST HAS TRAVELED 4.401869 HOURS WHEN BOTH MEET.


READY
```

EDUCATIONAL BENEFITS: Computers can be used as powerful calculators too.

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AREA: Mathematics NUMBER: NAME: GROUP
SOURCE: Digital Equipment Corp. LANGUAGE: BASIC
DESCRIPTION: This program illustrates a method of solving a mathematical word problem by trial and error using the computer. The problem is:

When 15 girls leave a group of boys and girls, there are 2 boys for each girl. After that, 45 boys leave. Then there are 5 girls for each boy. How many girls were in the group before anyone left?

USAGE: One must recognize that this problem requires the solution of two simultaneous equations. Letting G = the original number of girls and B = the original number of boys, the equations are:

$$(G - 15) \times 2 = B$$

$$(B - 45) \times 5 = (G - 15)$$

It is, of course, possible to substitute the value of B from Equation 1 into Equation 2 and solve for G. However, the computer permits us to get the solution by trial and error, obviously not a very sensible way to do the problem by hand.

The program below has been written to try all possible values of B and G between 1 and 100 until a solution is found or until the program runs out of combinations.

```
READY

 5 PRINT "PROGRAM GROUP"
 6 PRINT
10 FOR G=1 TO 100
20 FOR B=1 TO 100
25 LET I=I+1
30 IF 2*(G-15)<>B THEN 50
40 IF 5*(B-45)<>(G-15) THEN 50
45 PRINT G;"GIRLS",B;"BOYS"
48 GO TO 90
50 NEXT B
60 NEXT G
70 PRINT "NO SOLUTION"
90 PRINT I;"COMBINATIONS TRIED"
99 END

RUN

PROGRAM GROUP

 40 GIRLS       50 BOYS
 3950 COMBINATIONS TRIED


READY
```

EDUCATIONAL BENEFITS: The student can see that the computer can be employed to find a solution to a problem by trial and error, but that it must try 3950 possible solutions before the correct one is reached. Hence, if a problem can be easily solved by hand, the computer may not always be a significant advantage.

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AREA: Mathematics NUMBER: NAME: SIMUL
SOURCE: Digital Equipment Corp. LANGUAGE: BASIC
DESCRIPTION: The SIMUL program illustrates one way in which the computer can be used to solve relatively complex simultaneous equations.

USAGE: The computer can be used to solve simultaneous equations by trial and error far faster than we humans can. For example, let's solve for x and y in the following equations:

$$2^x = \frac{16y}{3} \quad \text{and} \quad 3^x = 27y$$

The program, which tries values of x and y between 0 and 100 until it reaches a solution or runs out of values is as follows:

```
 5 PRINT "PROGRAM SIMUL"
 6 PRINT "SOLUTION TO TWO SIMULTANEOUS EQUATIONS"
 7 PRINT
10 FOR X=1 TO 100
20 FOR Y=1 TO 100
30 IF 2↑X<>16*Y/3 THEN 50
40 IF 3↑X<>27*Y THEN 50
45 PRINT "X =";X,"Y =";Y
48 GO TO 99
50 NEXT Y
60 NEXT X
70 PRINT "NO INTEGER SOLUTION"
99 END

READY

RUN

PROGRAM SIMUL
SOLUTION TO TWO SIMULTANEOUS EQUATIONS

X = 4          Y = 3


READY
```

Let's try the same problem, but change Equation 2 slightly.

```
10 FOR X=1 TO 10
20 FOR Y=1 TO 10
40 IF 3*X<>28*Y THEN 50

RUN

PROGRAM SIMUL
SOLUTION TO TWO SIMULTANEOUS EQUATIONS

NO INTEGER SOLUTION


READY
```

Oh, Oh. What went wrong?

EDUCATIONAL BENEFITS: The student can see that trial and error, at least incrementing by whole numbers, does not always yield a solution, even trying 10,000 combinations. There must be another, better way.

Hint: Try combining the two equations and getting a solution for x using program ROOT. Then y can be easily solved for.

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AREA: Mathematics NUMBER: NAME: BOOKS
SOURCE: Digital Equipment Corporation LANGUAGE: BASIC
DESCRIPTION: This program illustrates the solution to a fairly simple word problem involving two simultaneous equations. Then, by combining the equations and trying fewer combinations, the speed of obtaining the solution can be improved 100 fold. The problem is:

Brown has 48 books; some are worth $3 each, some $5 and others $8. The total value of the books is $175. How many of each kind are there if there are an even number of $5 books?

USAGE: The equations for solution are (letting T = number of three dollar books; F = five dollar books and E = eight dollar books):

$$T + F + E = 48$$

$$T * 3 + F * 5 + E * 8 = 175$$

If we then try all possible combinations of T, F, and E from 1 to 48 for each variable, our program would be as follows:

```
 5 PRINT "ALL POSSIBLE SOLUTIONS FOR BOOKS PROBLEM"
 6 PRINT
 7 PRINT "T","F","E"
 8 PRINT
10 FOR T=1 TO 48
20 FOR F=1 TO 48
30 FOR E=1 TO 48
40 IF (T+F+E)<>48 THEN 70
50 IF (T*3+F*5+E*8)<>175 THEN 70
60 PRINT T,F,E
70 NEXT E
80 NEXT F
90 NEXT T
99 END
```

```
RUN

BOOKS           21:03           22-JAN-71


ALL POSSIBLE SOLUTIONS FOR BOOKS PROBLEM

T               F               E

 34              13              1
 37              8               3
 40              3               5

TIME:  7.31 SECS.

READY
```

However, 7.31 seconds is a long time for the computer to work. Let's solve for T in both equations by hand and solve the resulting equation by brute force on the computer:

$$F * 2 + E * 5 = 31$$

In this equation, we can also reduce our limits since we recognize that F cannot be greater than 31/2 = 15.5 and E cannot be greater than 31/5 = 6.2. Making the appropriate program modifications leads to:

```
10
20 FOR F=1 TO 15
30 FOR E=1 TO 6
40 IF (F*2+E*5)<>31 THEN 70
50
55 LET T=48-F-E
90

RUN

BOOKS           21:06           22-JAN-71


ALL POSSIBLE SOLUTIONS FOR BOOKS PROBLEM

T               F               E

 40              3               5
 37              8               3
 34              13              1

TIME:  0.16 SECS.

READY
```

Our final refinement is to step F in increments of 2 since we know it must be even.

```
5 PRINT "SOLUTIONS FOR BOOKS PROBLEM WITH F = EVEN NUMBER"
20 FOR F=2 TO 14 STEP 2

RUN

BOOKS          21:10          22-JAN-71


SOLUTIONS FOR BOOKS PROBLEM WITH F = EVEN NUMBER

T              F              E

 37             8              3

TIME:  0.06 SECS.

READY
```

EDUCATIONAL BENEFIT: Notice the enormous improvement in computing time required for a solution 7.31 seconds to .06 seconds. Brute force certainly is inefficient! Perhaps it's worthwhile to think through most problems, particularly big ones. The computer may be fast, but we just improved its performance by 100 times using a little common sense!

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AREA: Mathematics NUMBER: NAME: SETS-1
SOURCE: CAMP First Course, Scott, Foresman and Company
LANGUAGE: BASIC
DESCRIPTION: Program to determine the intersection of two sets of numbers.

USAGE: Two sets of numbers can be combined to yield a third set by the operation of intersection. The intersection of two sets A and B is the set that contains all elements that belong to both A and B. It does not contain any other elements. The intersection is usually written A∩B.

For example, if M = { 0,2,4,6 } and K = { 1,2,3,4}, then M∩K = { 2,4 } .

The computer can be instructed to find the intersection of two sets. A program for finding the intersection of set x = { 1,3,5,---19 } and y = { 2,5,8,---29 } is written below

```
 5 PRINT "PROGRAM SETS-1"
 6 PRINT
 7 PRINT "THE INTERSECTION OF SETS X AND Y IS:"
10 FOR X=1 TO 19 STEP 2
20 FOR Y=2 TO 29 STEP 3
30 IF X=Y THEN 70
40 NEXT Y
50 NEXT X
60 GO TO 99
70 PRINT X
80 GO TO 50
99 END

RUN

PROGRAM SETS-1

THE INTERSECTION OF SETS X AND Y IS:
 5
 11
 17


READY
```

Using the computer, complicated sets which would be tedious to do by hand may be examined by defining one or both sets in a data statement. In the following example, set y is the same as above, but set x is given in the DATA statement.

```
  5 PRINT "PROGRAM SETS-1"
  6 PRINT
  7 PRINT "THE INTERSECTION OF SETS X AND Y IS:"
 10 READ X
 20 FOR Y=2 TO 29 STEP 3
 30 IF X=Y THEN 70
 40 NEXT Y
 50 GO TO 10
 70 PRINT X
 80 GO TO 10
 90 DATA 2,3,8,9,14,15,20,21,26,27
 99 END

READY


RUN

PROGRAM SETS-1

THE INTERSECTION OF SETS X AND Y IS:
 2
 8
 14
 20
 26

OUT OF DATA IN LINE 10


READY
```

EDUCATIONAL BENEFITS: The student is able to see that if there is a numerical pattern in the sets which intersect, there is also a pattern in the resultant intersecting set. In the first example above, for instance, set x steps by 2 and set y steps by 3, hence the intersecting set steps by 2 x 3 = 6. More complicated sets can be examined by computer than can easily be done by hand.

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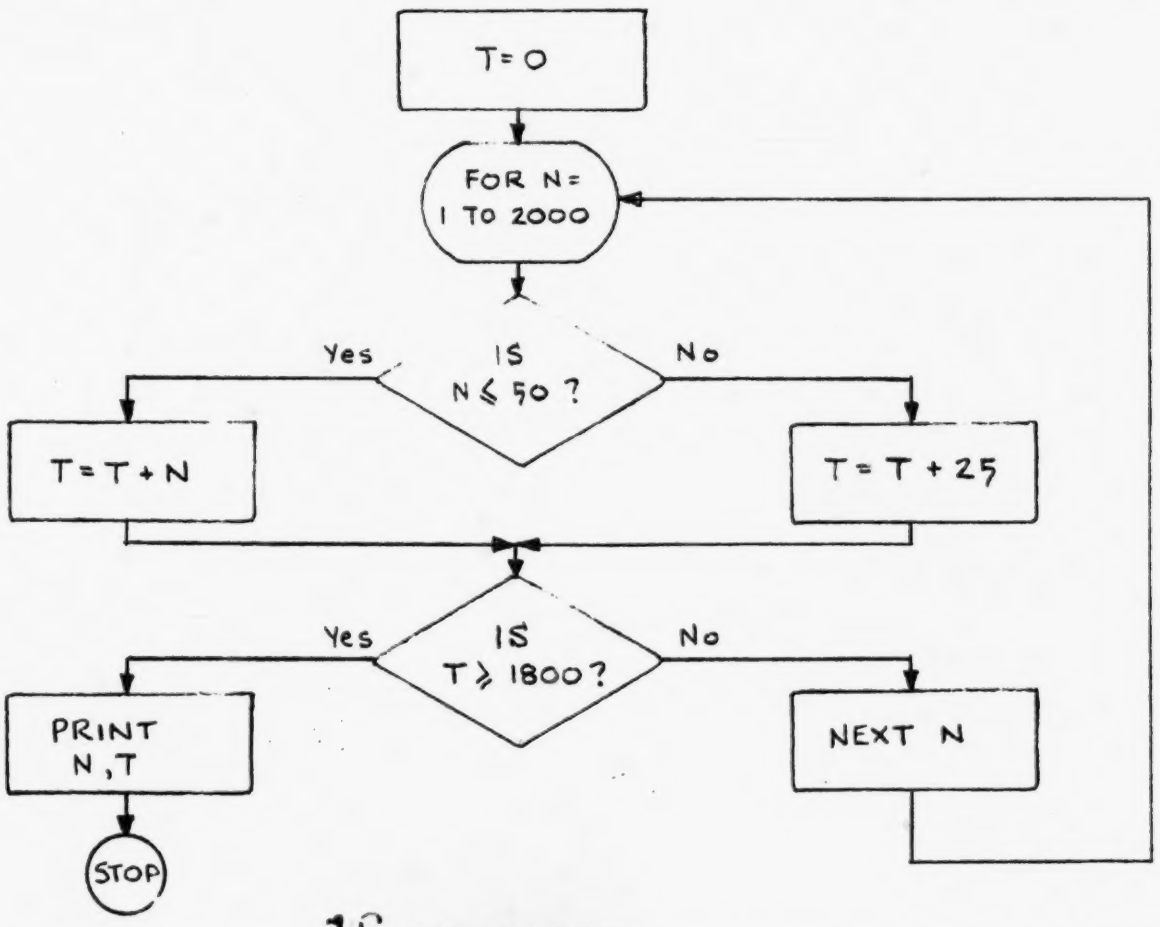
AREA: Mathematics NUMBER: NAME: TICKET
SOURCE: Digital Equipment Corp. LANGUAGE: BASIC
DESCRIPTION: This program introduces the concept of logical branching through the vehicle of a simple word problem:

At a PTA fair, they wish to dispose of an article valued at $18.00 by selling tickets. These tickets are numbered consecutively beginning with one. Each person drawing a ticket pays in cents an amount equal to the number on the ticket, if that number is 50 or less. If the number drawn is greater than 50, he pays just 25¢. How many tickets must be sold so the PTA exactly breaks even?

USAGE: Letting T = the total money collected and N = the number of tickets sold, we can set up a flow chart to calculate the total money collected after each additional ticket is sold and compare that sum to $18.00.



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Having the flow chart puts us just one step away from the program and a solution to the problem.

```
 5 PRINT "PROGRAM TICKET"
 6 PRINT
10 LET T=0
15 FOR N=1 TO 2000
20 IF N<=50 THEN 40
25 LET T=T+25
30 GO TO 50
40 LET T=T+N
50 IF T>=1800 THEN 70
60 NEXT N
70 PRINT N;"TICKETS SOLD TO COLLECT EXACTLY $";T/100
99 END

RUN

PROGRAM TICKET

 71 TICKETS SOLD TO COLLECT EXACTLY $ 18


READY
```

EDUCATIONAL BENEFITS: This problem can be done longhand, in which case it is extremely tedious. On the other hand, most students using a short cut method will get the wrong answer (72). So we see how the computer using logical branching can help us solve a deceptively simple problem quickly and correctly.

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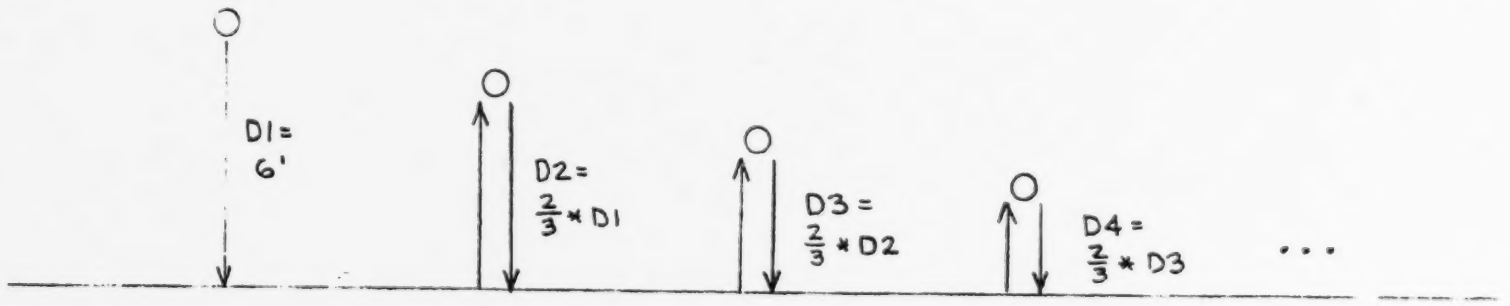
AREA: Mathematics NUMBER: NAME: BASKT
SOURCE: Digital Equipment Corp. LANGUAGE: BASIC
DESCRIPTION: This program illustrates how the computer can be used to solve a problem using exponential convergence. The problem is:

Holding a ball six feet from the floor and letting it drop, a basketball player noticed that the ball bounced back up only two-thirds of that height (four feet). On the second bounce, the ball rose to only two thirds of the second height (two feet, eight inches). The third bounce brought it to two-thirds of the previous height, and so on. What was the total distance the ball traveled--both up and down--before it came to rest?

USAGE: A diagram can be used to show how far the ball bounces each time.



We notice that after the 1st bounce, the ball has traveled (at floor level):

$$D1 + 2 * D2 \quad \text{or} \quad D1 + 2* (2/3 * D1)$$

and that after 2 bounces, the ball has traveled:

$$D1 + 2*D2 + 2*D3 = D1 + 2*(2/3*D1) + 2*(2/3 * 2/3 * D1)$$

Hence, with each additional bounce, the ball travels an additional distance of:

$$2*D1*(2/3)^n \quad \text{or} \quad 12*(2/3)^n$$

Now it is a simple matter to write a program which increments the total distance traveled and print out the results after each bounce.

```
1 PRINT "PROGRAM BASKT"
2 PRINT
3 PRINT "BOUNCES","DISTANCE"
4 PRINT
5 LET D=6
10 FOR X=1 TO 50
20 LET D=D+12*(2/3)↑X
30 PRINT X,D
40 NEXT X
99 END

RUN

PROGRAM BASKT

BOUNCES        DISTANCE

 1              14
 2              19.33333
 3              22.88889
 4              25.25926
 5              26.83951
 6              27.893
 7              28.59534
 8              29.06356
 9              29.3757
 10             29.5838
 11             29.72253
 12             29.81502
 13             29.87668

 32             29.99994
 33             29.99996
 34             29.99997
 35             29.99998
 36             29.99998
 37             29.99999
 38             29.99999
 39             29.99999
 40             29.99999
 41             29.99999
 42             29.99999
 43             29.99999
 44             29.99999
 45             29.99999
 46             29.99999
 47             29.99999
 48             29.99999
 49             29.99999
 50             29.99999

READY
```

EDUCATIONAL BENEFIT: The student can see, by means of a contemporary example, how a progression can be used to solve a problem. He also learns to solve a problem which would be quite difficult to do by hand, especially after the first few terms.

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AREA: Mathematics NUMBER: NAME: PROGRS
SOURCE: Digital Equipment Corp. LANGUAGE: BASIC

DESCRIPTION: Sometimes the computer is used to do a problem in an entirely different way than we humans might approach the same problem. For example, given the following tables of values:

X	1	2	3	4	etc.
Y	10	17	26	37	

What is the value of X when Y is 2602?

APPROACH: We noticed that the difference between successive values of Y increases by 2 each step; i.e., 7, 9, 11, etc. Therefore, if we stepped from Y = 10 to 2602 in steps of Z, the step itself would have to be incremented by 2 for each new step. If we write a program to do this as well as count the number of steps, X, we should be able to solve the problem.

```
 5 PRINT "PROGRAM PROGRS"
 6 PRINT
10 LET X=1
20 LET Z=7
25 LET Y=10
30 LET Y=Y+Z
40 LET Z=Z+2
50 LET X=X+1
60 IF Y<2602 THEN 30
80 PRINT "X =";X,"Y =";Y
99 END

READY

RUN

PROGRAM PROGRS

X = 49          Y = 2602


READY
```

EDUCATIONAL BENEFIT: It's often possible to solve a problem using the computer in a manner quite differently than one would use by hand. How would you have solved this problem not using the computer?

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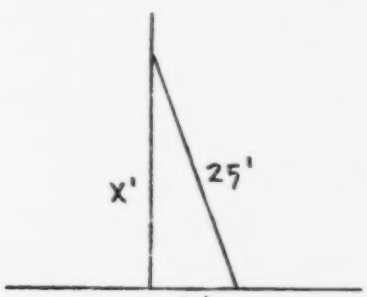
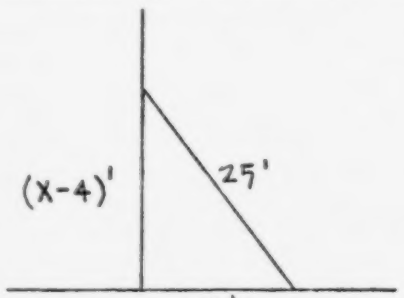
AREA: Geometry NUMBER: NAME: LADDER
SOURCE: Digital Equipment Corporation LANGUAGE: BASIC
DESCRIPTION: The ladder program shows how the computer can be used to calculate the solution to the following word problem:

A ladder 25 feet long is placed so that its foot is 7 feet from the base of a building. When the top of the ladder slipped 4 feet down the side of the building, how far did the foot of the ladder slip?

USAGE: The diagrams below show the two ladder positions.





By the Pythagorean theorem we know that $a^2 + b^2 = c^2$, hence, the equations needed to solve the above problem are:

$$x = \sqrt{25^2 - 7^2}$$

$$y = \sqrt{25^2 - (x-4)^2}$$

and the amount of slippage of the base is:

$$z = y - 7$$

The program to do the problem is as follows:

```
READY

 5 PRINT "PROGRAM LADDER"
 6 PRINT
10 LET X=SQR(25*25-7*7)
20 LET Y=SQR(25*25-(X-4)*(X-4))
30 LET Z=Y-7
40 PRINT "LADDER BASE SLIPPED";Z;"FEET."
99 END

RUN

PROGRAM LADDER

LADDER BASE SLIPPED 8 FEET.


READY
```

EDUCATIONAL BENEFITS: While the arithmetic in the problem above is not particularly "messy", it still is no great joy to solve by hand. However, the computer would be equally happy to do the problem if the ladder is 27.83 feet long and it was 7.62 feet from the wall originally. Would you?

```
10 LET X=SQR(27.83↑2-7.62↑2)
20 LET Y=SQR(27.83↑2-(X-4)↑2)
30 LET Z=Y-7.62

RUN

PROGRAM LADDER

LADDER BASE SLIPPED 8.386132 FEET.


READY
```

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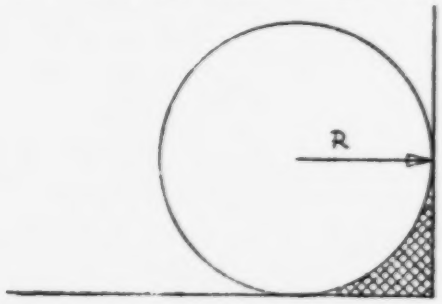
AREA: Geometry NUMBER: NAME: Area-1
SOURCE: Computer Methods in Mathematics LANGUAGE: BASIC

DESCRIPTION: The problem is to solve for the shaded area of the figure below for any value of the radius, R.



APPROACH: We start by remembering that the area of a circle and square are calculated as follows:

$$A_{circle} = \pi * R^2$$

$$A_{square} = SIDE^2 \text{ or } (2 * R)^2$$

The difference in area between a square and a circle inscribed within its borders is:

$$\Delta A = A_{square} - A_{circle}$$

and the area of one corner is:

$$A_{corner} = \Delta A/4$$

Now, let's write the program to perform this calculation for any input value of R.

EDUCATIONAL BENEFITS: By trying different values of R, the student can determine relationships in areas as a function of the components. Let's try several values of R and see what happens.

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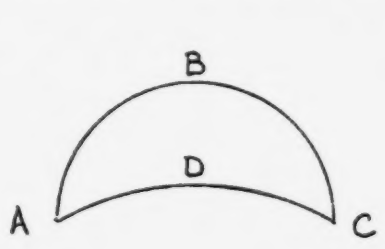
```
 5 PRINT "PROGRAM AREA-1"
 6 PRINT
 7 PRINT "WHAT IS THE RADIUS";
 8 INPUT R
 9 PRINT
10 LET P=3.14159
20 LET A1=P*R↑2
30 LET A2=(2*R)↑2
40 LET D=(A2-A1)/4
50 PRINT "AREA OF ENCLOSED CORNER IS";D
99 END

RUN

PROGRAM AREA-1

WHAT IS THE RADIUS? 1

AREA OF ENCLOSED CORNER IS .2146025


READY

RUN

PROGRAM AREA-1

WHAT IS THE RADIUS? 10

AREA OF ENCLOSED CORNER IS 21.46025

READY

RUN

PROGRAM AREA-1

WHAT IS THE RADIUS? 100

AREA OF ENCLOSED CORNER IS 2146.025

READY

RUN

PROGRAM AREA-1

WHAT IS THE RADIUS? 2.158652

AREA OF ENCLOSED CORNER IS 1

READY
```

DIGITAL EQUIPMENT CORPORATION

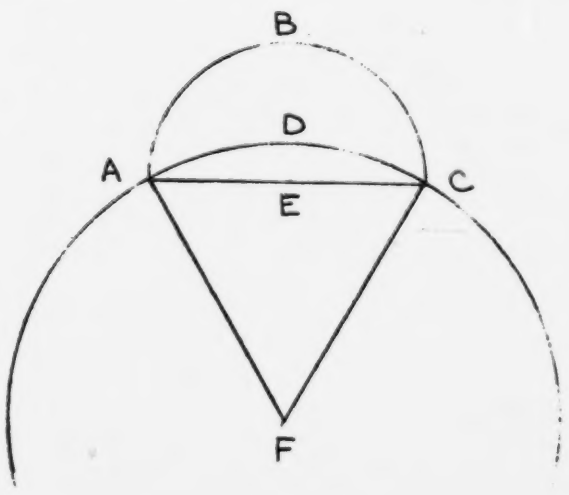
education

AREA: Geometry NUMBER: NAME: CRSCNT
SOURCE: Digital Equipment Corp. LANGUAGE: BASIC

DESCRIPTION: The computer is used to aid in the solution of the following problem. A crescent figure is bounded by a semicircle ABC whose radius is 5 inches and an arc ADC, the radius of whose circle is 10 inches. Find the area of the crescent.



APPROACH: In this problem, like any in which the computer is used, the student must recognize the fundamental formulae and algorithms to be used. If he cannot do that, he is stuck. To aid us in completing this problem, it will be helpful to complete the drawing to show more of both circles.



R1 = radius of small circle = 5
R2 = radius of big circle = 10

Some things should now be apparent. In particular, since ABC is a semicircle, distance AEC is equal to 2*R1 = 10. Hence, triangle ACF is equilateral. Therefore, the area of wedge ADCF equals 1/6

the area of the large circle. Hence, the area of the crescent is:

$$\text{Area}_{\text{crescent}} = \text{Area ABCE} - \text{Area ADCE}$$

$$= \frac{1}{2} * \text{Area}_{\text{small circle}} - \left[\text{Area}_{\text{wedge}} - \text{Area}_{\text{triangle}}\right]$$

$$= \frac{1}{2} * \pi * R1^2 - \left[\frac{1}{6} * \pi * R1^2 - \frac{1}{2} * R2 * \sqrt{R2^2 - \left(\frac{R2}{2}\right)^2}\right]$$

We can now substitute 5 and 10 for R1 and R2, reduce the equations and solve. The typical math text would ask that the answer be left in radical form and not figured for π. After a good bit of manipulation, the student would finally get down to an answer of:

$$\text{Area}_{\text{crescent}} = 25 * \left(\sqrt{3} - \frac{\pi}{6}\right)$$

However, using the computer, we can get a final solution without a lot of hand reduction.

```
10 LET P1=3.14159
20 PRINT "AREA OF CRESCENT IN SQUARE INCHES IS";
30 PRINT 1/2*P1*5↑2-1/6*P1*10↑2+1/2*10*SQR(10↑2-5↑2)
99 END

READY

RUN

AREA OF CRESCENT IN SQUARE INCHES IS 30.21131


READY
```

EDUCATIONAL BENEFITS: The student can see that the computer won't help him much unless he knows the problem fundamentals and can "teach" the computer how to help him. He also learns that the computer is happy to grind through calculations that aren't very pleasant to do by hand. Of course, if he wants to reduce the equation as far as possible and then use the computer, that approach works too.

```
10 LET P1=3.14159
20 PRINT "AREA OF CRESCENT IN SQUARE INCHES IS";
30 PRINT 25*(SQR(3)-P1/6)
99 END

READY

RUN

AREA OF CRESCENT IN SQUARE INCHES IS 30.21131


READY
```

DIGITAL EQUIPMENT CORPORATION

education

AREA: Statistics NUMBER: NAME: FLIP-1
SOURCE: Basic BASIC, Hayden Publishing Co. LANGUAGE: BASIC

DESCRIPTION: This program makes use of the random number generator in BASIC to flip an imaginary coin and do a simple tabulation of the number of heads which come up. Ten sequences of 50 flips are tabulated.

APPROACH: Since the random number generator, RND, produces numbers between 0 and 1, we must have a way of splitting the numbers in half. One way, of course, is to ask whether the random number generated is greater or less than .5. Another way, which illustrates the use of the integer function, is as follows. Multiply the random number generated by 2 and then take the largest integer value contained in the result. If 0, let it be a tail; 1, a head. The statement to set the value of the flip is:

```
LET F = INT (2 * RND (1) )
```

Now, let's see what the whole program looks like.

```
  1 PRINT "PROGRAM FLIP-1"
  4 FOR Y=1 TO 10
  5 LET C=0
 10 FOR X=1 TO 50
 20 LET F=INT(2*RND(1))
 30 IF F=1 THEN 60
 40 PRINT "T";
 50 GO TO 100
 58 REM  C COUNTS THE NUMBER OF HEADS
 60 LET C=C+1
 70 PRINT "H";
100 NEXT X
110 PRINT
120 PRINT "HEADS";C;"OUT OF 50 FLIPS"
122 PRINT
125 NEXT Y
999 END
```

```
READY

RUN

PROGRAM FLIP-1
TTHTTTTTHTTTTHTHTTHHHTTTTHHHTTHHHHHTHHHHHHTTHHTTHT
HEADS 24 OUT OF 50 FLIPS

THTTHHHTHHTHHHHTTTHTHTHHTTHHHHHHTTTHHTHTTHTTTTTHTT
HEADS 25 OUT OF 50 FLIPS

THTTHTHHTTTHHHHHTHTHTTHHHTTHTHHTTHHTHHTTHTTHTHTHTT
HEADS 25 OUT OF 50 FLIPS

THTTTHTTTTHHHHHHHTHHTTHTTTTHHHHTHTTTTHTTHTHHTTTHT
HEADS 23 OUT OF 50 FLIPS

THTHTHTTTHHTHTTTHTTTHTHTTTHHTTTTTTHTHTTHHHHTHTHHTT
HEADS 21 OUT OF 50 FLIPS

THHHTHHTTTHHTHTHTHHHTHTHTTTTTTTTHHTHHHHHTTHHTTTHTH
HEADS 25 OUT OF 50 FLIPS

THHTHTHHTHHTHHTHTHHHHHTTHTTHHHHTHHTTTHTHHHHTTHHHT
HEADS 31 OUT OF 50 FLIPS

TTTHTTTTHTHHTTHTHTHTHTTHHTTHTTTHTHHHTHHHHTHHHHHHH
HEADS 27 OUT OF 50 FLIPS

HHHHTHHHHHTHHHTHTHHTTHHHHTTHHTTHTHTHHTTTTTHTTTHHH
HEADS 29 OUT OF 50 FLIPS

TTTHTHTTTTTTHTHTHTTTHTTHHTHTHHHTTHHHTHHHTHTHHHTHTT
HEADS 23 OUT OF 50 FLIPS
```

A simple addition lets us compute the percentage of all 500 flips which were heads.

```
2 LET C1=0
65 LET C1=C1+1
130 LET A=C1*100/500
133 PRINT
135 PRINT A;"% OF 500 FLIPS WERE HEADS"

RUN

PROGRAM FLIP-1
TTHTTTTTHTTTTHTHTTHHHTTTTHHHTTHHHHHTHHHHHHTT"
HEADS 24 OUT OF 50 FLIPS
                                        ...THHHHHHHH
THTTHHHTHHTHHHHTTTHTH"
HEADS 25 OUT O
                    ...HTTHHHHTTHHTTHTHTHHTTTTTHTTTTHHH
          OUT OF 50 FLIPS

TTTHTHTTTTTTHTHTHTTTHTTHHTHTHHHTTHHHTHHHTHTHHHTHTT
HEADS 23 OUT OF 50 FLIPS


 50.6 % OF 500 FLIPS WERE HEADS

READY
```

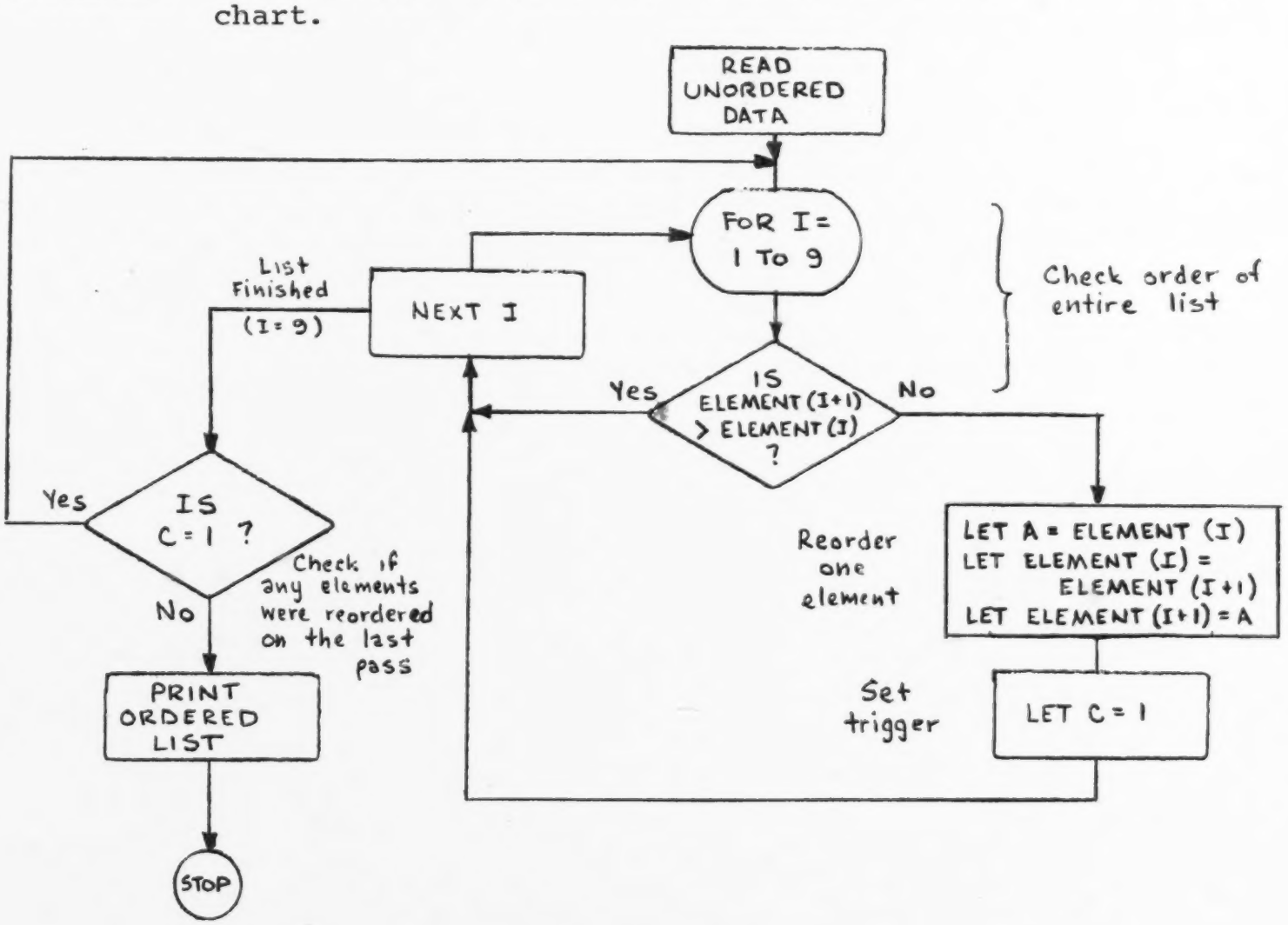
DIGITAL EQUIPMENT CORPORATION

education

AREA: Business NUMBER: NAME: SORT-1
SOURCE: Digital Equipment Corp. LANGUAGE: BASIC

DESCRIPTION: In business data processing, it is frequently necessary to sort a list of data into order. For example, some lists must be sorted by age, zip code, weight, inventory level, etc. This program is one way in which sorting can be done. The problem is to read in 10 numbers as DATA and then print them out sorted from smallest to largest.

APPROACH: In this type of problem, it is best to start with a flow-chart.



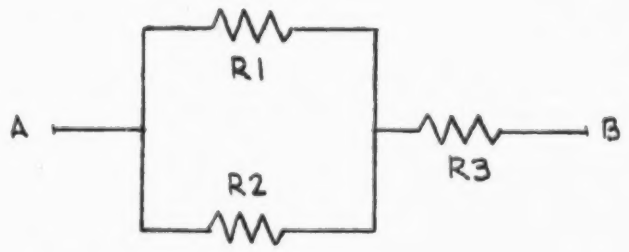
```
READY

LIST
   2 DIM A(10),I(10)
   5 PRINT "RANDOMLY ORDERED DATA"
  10 FOR I=1 TO 10
  20 READ A(I)
  30 PRINT A(I);
  40 NEXT I
  50 LET C=0
  55 REM  CHECK IF ALL ELEMENTS IN LIST ARE ORDERED
  60 FOR I=1 TO 9
  70 IF A(I+1)<A(I) THEN 200
  80 NEXT I
  85 REM  C INDICATES IF AN ELEMENT WAS REORDERED
  90 IF C=0 THEN 300
 100 GO TO 50
 195 REM  REORDER ONE ELEMENT
 200 LET A=A(I)
 210 LET A(I)=A(I+1)
 220 LET A(I+1)=A
 230 LET C=1
 240 GO TO 80
 300 PRINT
 301 PRINT
 302 PRINT "ORDERED DATA"
 310 FOR I=1 TO 10
 320 PRINT A(I);
 330 NEXT I
 400 DATA 10,5,1,9,4,8,3,7,2,6
 999 END

READY

RUN

RANDOMLY ORDERED DATA
 10  5  1  9  4  8  3  7  2  6

ORDERED DATA
 1  2  3  4  5  6  7  8  9  10

READY



400 DATA 62,64,89,100,95,73,50,95,80,87

RUN

RANDOMLY ORDERED DATA
 62  64  89  100  95  73  50  95  80  87

ORDERED DATA
 50  62  64  73  80  87  89  95  95  100

READY
```

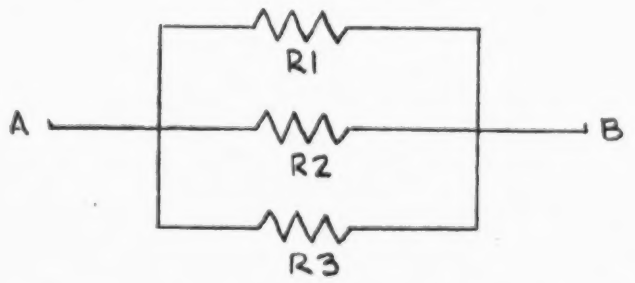
DIGITAL EQUIPMENT CORPORATION

education

AREA: Electricity NUMBER: NAME: Resist
SOURCE: Computer Methods in Mathematics LANGUAGE: BASIC

DESCRIPTION: The problem is to computer the equivalent resistance between points A and B for the circuits below:





APPROACH: We must remember that in series, resistance is additive, that is:

$$R_T = R_1 + R_2 \text{ ---}$$

Whereas in parallel, the resultant resistance is computed as follows:

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} \text{ ---}$$

Given these relationships, it is a simple matter to write a program to compute the resultant resistance for the two circuits above.

```
 5 PRINT "PROGRAM RESIST"
 6 PRINT
10 PRINT "R1";
15 INPUT R1
20 PRINT "R2";
25 INPUT R2
30 PRINT "R3";
35 INPUT R3
40 LET R4=1/(1/R1+1/R2)+R3
50 PRINT
60 PRINT "R4 =";R4
99 END
```

```
RUN

PROGRAM RESIST

R1? 330
R2? 220
R3? 110

R4 = 242


READY

RUN

PROGRAM RESIST

R1? 10
R2? 10
R3? 10

R4 = 15


READY
```

For the second circuit, we need change only one statement in our program:

```
40 LET R4=1/(1/R1+1/R2+1/R3)

RUN

PROGRAM RESIST

R1? 330
R2? 220
R3? 110

R4 = 60


READY

RUN

PROGRAM RESIST

R1? 10
R2? 10
R3? 10

R4 = 3.333333


READY
```

EDUCATIONAL BENEFITS: The computer can be used as a tool to aid in solving all kinds of practical problems. It is not necessary for a student to get bogged down in mathematical calculations when he is eagerly learning about other things.

$1.25

DIGITAL EQUIPMENT CORPORATION

education

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Basic Applications Programs (Set 2)

ED052610

EM009 064-2

BASIC APPLICATION PROGRAMS

-Set 2-

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The programs contained in this series are designed to demonstrate how the computer can be applied in a meaningful way to problems of many disciplines. The problems and the corresponding programs are, for the most part, quite simple and are designed to be "jumping off points" for students from the high school level on up.

All of the programs, with very few exceptions, may be run on EduSystems 10 through 90, PDP-8 family and PDP-11 family computers. Exceptions are noted in the program descriptions.

Additional copies of BASIC Applications Programs may be obtained from:

Direct Mail Department
Digital Equipment Corporation
Maynard, Massachusetts 01754

Price:	Set 1 (15 problems)	$1.00
	Set 2 (19 problems)	$1.25

BASIC APPLICATION PROGRAMS

Table of Contents (Sets 1 and 2)

Mathematics	BASKT	Demonstrates exponential convergence.
	BICYCL	Solves simple time-speed-distance problem.
	BOOKS	Demonstrates method of improving upon brute force to solve simultaneous equations.
	CONVRG	Converges on e and π by 3 methods.
	DRINKR	Solves simple drinking/blood pressure relationship.
	GROUP	Demonstrates brute force vs. substitutional solution of simple equations.
	PASCAL	Method of generating Pascal's triangle using random numbers.
	PLOTFN	Plots any function.
	PROGRS	Solves a number progression problem.
	QUADRT	Solves for the roots of a quadratic equation.
	ROOTS	Finds the roots of any function between -20 and 20.
	ROUNDOFF	Rounds off numbers to any number of places.
	SETS-1	Determines the intersection of two sets of numbers.
	SIMUL	Solves simultaneous equations by brute force.
	TICKET	Introduces the concept of logical branching.
	TUTOR-1	Drill and practice with time-speed-distance problems.
GAMES	GUESS	Binary search guessing game vs. the computer.
	LUNAR2	Simulates the landing of a lunar module on the moon.

Geometry	AREA-1	Solves for the area under a curve by equation.
	CRSCNT	Solves for the area of a crescent (not generalized).
	LADDER	Solves the slipping ladder problem by Pythagorean theorem.
Plotting	DIAMON	Plots an N by N diamond matrix.
	PLOTFN	Plots any function
	SINEX	Plots a sine wave
	3DPLOT	Plots any three dimension functions.
Statistics	FLIP-1	Flips a coin.
	GUESS	Binary search guessing game vs. the computer.
Business	DEPRECIATE	Demonstrates 3 methods of depreciation.
	ROUNDOFF	Rounds off numbers to any number of places.
	SORT-1	Sorts a list of numbers.
Biology	EVOLU	Demonstrates evolutionary mutations of pepper moths.
Physics	KINEMA	Tests knowledge of kinematics.
	LUNAR2	Simulates the landing of a lunar module on the moon.
	PHOTOE	Demonstrates photo electric effect.
	UELEC	Produces tables of electric potential.
Electronics	INDUC	Determines value of an unknown inductor.
	RESIST	Computes equivalent resistance for resistor networks.

DIGITAL EQUIPMENT CORPORATION

education

AREA: Mathematics NUMBER: NAME: CONVRG
SOURCE: Digital Equipment Corp. LANGUAGE: BASIC
DESCRIPTION: The CONVRG series of programs will calculate:

1. by an infinite series.
2. π by inscribed and circumscribe polygon.
3. π by infinite series (1 - 1/3 + 1/5 - 1/7 + 1/9...)

APPROACH: The above methods are commonly taught to show how and may be accurately calculated; however, it is difficult to carry out the calculations very far using pencil and paper alone.

The portion of the program to converge on e using the series

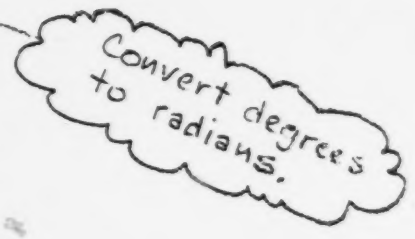
1 + 1/1 + 1/2 + 1/6 + 1/24 + 1/120 +...)

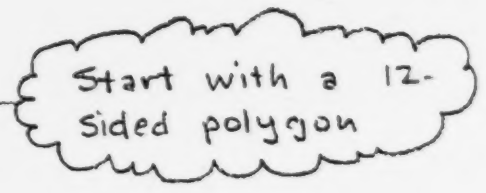
is as follows:

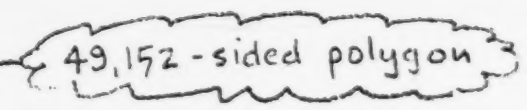
```
100 LET F=1
110 LET I=I+1
120 LET D=1
130 FOR J=1 TO I
140 LET D=D*J
150 NEXT J
160 LET F=F+1/D
170 PRINT F
180 GO TO 110
999 END

RUN

 2
 2.5
 2.666667
 2.708333
 2.716667
 2.718056
 2.718254
 2.718279
 2.718281
 2.718282
 2.718282
 2.718282
```

The portion of the program to converge on Pi by means of inscribed and circumscribed polygons is as follows:

```
 10 LET N=6
 20 LET N=2*N
 30 LET X=360/(N*57.29578)
 40 PRINT N*SIN(X)*COS(X)/2, N*TAN(X)/2
 50 GOTO 20
 99 END

READY

RUN

 2.598076        3.464102
 3               3.21539
 3.105829        3.15966
 3.132629        3.146086
 3.13935         3.142715
 3.141032        3.141873
 3.141453        3.141663
 3.141558        3.14161
 3.141584        3.141597
 3.141591        3.141594
 3.141592        3.141593
 3.141593        3.141593
 3.141593        3.141593

↑C
```

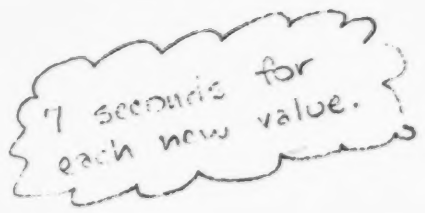






The third option, converging on Pi using an infinite series converges very slowly. Therefore, only every <u>500th</u> value is typed out.

```
300 LET S=1
310 LET I=1
320 LET C=C+1
330 LET P=P+S/I
340 LET I=I+2
350 LET S=-S
360 IF C<499 THEN 320
370 LET C=0
380 PRINT P*4
390 GO TO 320
999 END

RUN

 3.143597
 3.14059
 3.142261
 3.141091
 3.141994
 3.141259
 3.141879
 3.141342
 3.141816
 3.141392
 3.141775
 3.141426
 3.141748

↑C
```



DIGITAL EQUIPMENT CORPORATION

education

AREA: Mathematics NUMBER: NAME: GOLDBACH
SOURCE: CAMP First Course, Scott, Foresman and Co. LANGUAGE: BASIC

DESCRIPTION: This is the description of the program exercise as it appears in the CAMP text (page 200).

"Goldbach's Conjecture is one of the famous unproved theories in mathematics. Many people have searched for a counter-example to prove that the following claim is false: Every even number E greater than four is the sum of two odd prime numbers. Study the program "Goldbach" which will print out each even number E, where E<6<50, and two odd prime numbers whose sum is E. Examine the output from the computer. Does this program "prove" the conjecture.

The teacher's guide is quick to point out that it proves the conjecture for E≤50, but that's all.

USAGE: Load Goldbach and type RUN. No input is required. This program has nested loops which take time. Running time is in minutes.

EDUCATIONAL BENEFITS: The student has whole new ways to approach theorem proving when the computer is available to try lots of cases.

```
LIST


   5 PRINT "GOLDBACH"
  10 FOR E=6 TO 50 STEP 2
  15 FOR P=3 TO E-3
  20 FOR F=2 TO P-1
  25 IF P/F=INT(P/F) THEN 65
  30 NEXT F
  35 FOR N=3 TO E-3
  40 FOR D=2 TO N-1
  45 IF N/D=INT(N/D) THEN 60
  50 NEXT D
  55 IF P+N=E THEN 80
  60 NEXT N
  65 NEXT P
  70 PRINT "CONJECTURE FALSE FOR"E
  75 GO TO 99
  80 PRINT E"="P"+"N
  85 NEXT E
  99 END

READY

RUN

GOLDBACH
 6 = 3 + 3
 8 = 3 + 5
 10 = 3 + 7
 12 = 5 + 7
 14 = 3 + 11
 16 = 3 + 13
 18 = 5 + 13
 20 = 3 + 17
 22 = 3 + 19
 24 = 5 + 19
 26 = 3 + 23
 28 = 5 + 23
 30 = 7 + 23
 32 = 3 + 29
 34 = 3 + 31
 36 = 5 + 31
 38 = 7 + 31
 40 = 3 + 37
 42 = 5 + 37
 44 = 3 + 41
 46 = 3 + 43
 48 = 5 + 43
 50 = 3 + 47


READY
```

DIGITAL EQUIPMENT CORPORATION

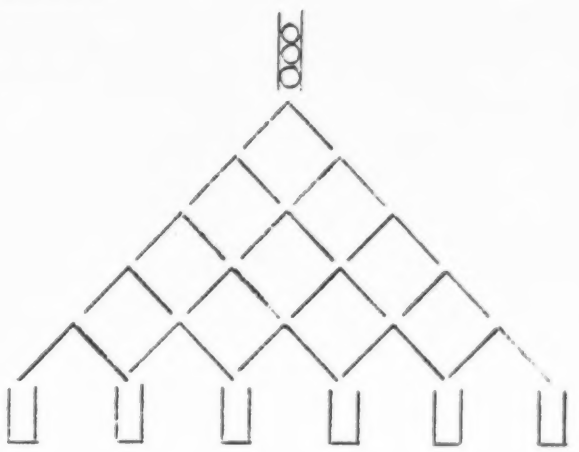
education

AREA: Mathematics NUMBER: NAME: PASCAL
SOURCE: Digital Equipment Corp. LANGUAGE: BASIC

DESCRIPTION: This program simulates the dropping of N balls through the following array of K levels. It is assumed that each ball is equally likely to fall to the left or right at each point in the array. After each group of balls has been dropped, the number of balls in each basket (from left to right) is typed out.

The number of balls landing in the various "baskets" at each level, when reduced to the lowest common denominator, should approximate the numbers in Pascal's Triangle. Do they? Write a program to determine how close you come. You should be able to observe many interesting things about Pascal's Triangle. What are the sums of the numbers in each row? What is the progression of numbers in each diagonal?

```
  5 PRINT "PROGRAM PASCAL"
  6 PRINT
 10 DIM B(10)
 15 PRINT "HOW MANY BALLS";
 16 INPUT M
 17 PRINT "HOW MANY LEVELS";
 18 INPUT K
 20 PRINT
 30 FOR N=1 TO M
 35 LET T=0
 40 FOR L=1 TO K
 50 IF RND(1)>.5 THEN 100
 90 LET T=T+1
100 NEXT L
110 LET B(T+1)=B(T+1)+1
120 NEXT N
130 FOR L=1 TO (K+1)
140 PRINT L,B(L)
145 LET B(L)=0
150 NEXT L
160 GOTO 6
999 END

READY
```



Pascal's Triangle

```
RUN

PROGRAM PASCAL

HOW MANY BALLS? 1000
HOW MANY LEVELS? 1

 1                506
 2                494

HOW MANY BALLS? 1000
HOW MANY LEVELS? 2

 1                252
 2                501
 3                247

HOW MANY BALLS? 1000
HOW MANY LEVELS? 3

 1                117
 2                393
 3                376
 4                114

HOW MANY BALLS? 1000
HOW MANY LEVELS? 4

 1                56
 2                250
 3                366
 4                254
 5                74

HOW MANY BALLS? 1000
HOW MANY LEVELS? 5

 1                30
 2                135
 3                321
 4                317
 5                160
 6                37

HOW MANY BALLS? 1000
HOW MANY LEVELS? 6

 1                16
 2                102
 3                225
 4                323
 5                226
 6                93
 7                15

HOW MANY BALLS?
↑C

READY
```

DIGITAL EQUIPMENT CORPORATION

education

AREA: Mathematics NUMBER: NAME: QUADRT
SOURCE: Digital Equipment Corporation LANGUAGE: BASIC
DESCRIPTION: For any input values a, b, and c of a first degree quadratic equation ($ax^2 + bx + c = 0$), this program computes the roots of the equation.

APPROACH: Based on the quadratic theorem, given $ax^2 + bx + c = 0$, then

$$x = \frac{-b \pm \sqrt{b^2 - 42c}}{2a}$$

Assuming a, b, and c are real numbers, the following principles are applied:

1. If $b^2 - 4ac$ is positive, then the roots are real and unequal.
2. If $b^2 - 4ac$ equals 0, then the roots are real and equal.
3. If $b^2 - 4ac$ is negative, then the roots are imaginary and unequal.

The program and several sample runs are on the reverse.

```
RUN

THIS PROGRAM SOLVES FOR THE ROOTS OF A
QUADRATIC EQUATION.  PLEASE INPUT THE FOLLOWING:
VALUE OF A? 1
VALUE OF B? 2
VALUE OF C? 1

THE ROOTS ARE
-1


THIS PROGRAM SOLVES FOR THE ROOTS OF A
QUADRATIC EQUATION.  PLEASE INPUT THE FOLLOWING:
VALUE OF A? 0
VALUE OF B? 2
VALUE OF C? 4

THIS IS A FIRST DEGREE EQUATION.
```

```
READY

10 PRINT "THIS PROGRAM SOLVES FOR THE ROOTS OF A "
20 PRINT "QUADRATIC EQUATION.  PLEASE INPUT THE FOLLOWING:"
22 PRINT "VALUE OF A";
24 INPUT A
26 PRINT "VALUE OF B";
28 INPUT B
30 PRINT "VALUE OF C";
32 INPUT C
34 PRINT
35 LET R=B↑2-4*A*C
40 IF A<>0 THEN 50
45 PRINT "THIS IS A FIRST DEGREE EQUATION."
47 GOTO 90
50 PRINT "THE ROOTS ARE ";
55 IF R<0 THEN 80
56 PRINT
58 IF R=0 THEN 70
60 PRINT (-B+SQR(R))/2*A
62 PRINT (-B-SQR(R))/2*A
65 GOTO 90
70 PRINT -B/2*A
75 GOTO 90
80 PRINT "IMAGINARY"
82 PRINT (-B/2*A);" + ";SQR(-R)/2*A;" *I"
84 PRINT (-B/2*A);" - ";SQR(-R)/2*A;" *I"
90 END

RUN

THIS PROGRAM SOLVES FOR THE ROOTS OF A
QUADRATIC EQUATION.  PLEASE INPUT THE FOLLOWING:
VALUE OF A? 2
VALUE OF B? 5
VALUE OF C? 2

THE ROOTS ARE
-2
-.5


READY

RUN

THIS PROGRAM SOLVES FOR THE ROOTS OF A
QUADRATIC EQUATION.  PLEASE INPUT THE FOLLOWING:
VALUE OF A? 4
VALUE OF B? 2
VALUE OF C? 4

THE ROOTS ARE IMAGINARY
-.4   +   1.49193   *I
-.4   -   1.49193   *I


READY
```

DIGITAL EQUIPMENT CORPORATION

education

AREA: Mathematics NUMBER: NAME: ROOTS
SOURCE: Digital Equipment Corp. LANGUAGE: BASIC

DESCRIPTION: ROOT finds all the roots of a function (ANY FUNCTION!) between -20 and 20. The function may be quadratic, cubic, trigonometric or any combination.

APPROACH: The method used here involves evaluating the function at incremental values, finding places where the value of the function changes sign and then, by successive approximations, finding the zero point. This method is similar to the commonly taught "Newton's Method."

USAGE: Before typing RUN, enter the function to be evaluated as a DEF FNA(X) statement as line 100. Then type RUN. For example:

```
100 DEF FNA(X) = 2*X↑3+11*X↑2-31*X-18Ø

100 DEF FNA(X) = SIN(X)-.5

100 DEF FNA(X) = X-4
```

EDUCATIONAL BENEFITS: The average student (especially in high school) does not have a thorough understanding of the very important concept of solving a function, much less an ability to do so for functions of any complexity. The computer lets them become very knowledgeable and confident in this area.

```
LIST


 100 DEF FNA(X)=2*X↑3 + 11*X↑2 - 31*X - 180
 110 LET Z1=-200
 120 FOR I=-19.9 TO 20
 130 IF SGN(FNA(I))=SGN(FNA(I+1)) THEN 300
 140 LET K=I
 150 LET J=I+1
 160 IF FNA(K)<FNA(J) THEN 200
 170 LET Z=K
 180 LET K=J
 190 LET J=Z
 200 LET Z=(K+J)/2
 210 IF FNA(Z)<0 THEN 240
 220 LET J=Z
 230 GO TO 250
 240 LET K=Z
 250 IF ABS(FNA(Z))>5.0000000E-05 THEN 200
 260 LET Z=SGN(Z)*INT(ABS(Z)*10000+.5)/10000
 270 IF Z=Z1 THEN 300
 280 PRINT "F("Z")=0"
 290 LET Z1=Z
 300 NEXT I
 310 END

READY

100 DEF FNA(X)=X-4
RUN

F( 4 )=0


READY

100 DEF FNA(X)=SIN(X)-.5
RUN

F(-18.3259 )=0
F(-16.2315 )=0
F(-12.0428 )=0
F(-9.9483 )=0
F(-5.7596 )=0
F(-3.6651 )=0
F( .5236 )=0
F( 2.6179 )=0
F( 6.8068 )=0
F( 8.9011 )=0
F( 13.09 )=0
F( 15.1844 )=0
F( 19.3732 )=0


READY

100 DEF FNA(X)=2*X↑3 + 11*X↑2 - 31*X - 180
RUN

F(-5 )=0
F(-4.5 )=0
F( 4 )=0
```

DIGITAL EQUIPMENT CORPORATION

education

AREA: Mathematics NUMBER: NAME: TUTOR-1
SOURCE: Walter Koetke, Lexington High School LANGUAGE: BASIC

DESCRIPTION: An effective technique for stimulating interest as well as for teaching methods of solving word problems is to have students write a program which will create and present a problem, ask the user to solve the problem, and then verify the user's response. For example, consider the problem:

A car traveling C (have computer generate an integer 40 through 65) miles per hour can make a certain trip in D (have computer generate an integer 5 through 20) hours less than a train traveling at T (have computer generate an integer 20 through 39) miles per hour. How long does the trip take by car?

The student's program should type out this problem with numbers generated by the random function appropriately substituted, then ask for the user's solution, the student's program must also correctly solve the problem. A program which does all of this is:

```
 5 RANDOMIZE
10 LET C=INT(RND(0)*25)+40
15 LET D=INT(RND(0)*15)+5
20 LET T=INT(RND(0)*19)+20
25 PRINT "A CAR TRAVELING"C"MPH CAN MAKE A CERTAIN TRIP IN"
 30 PRINT D"HOURS LESS THAN A TRAIN TRAVELING AT"T"MPH."
 35 PRINT "HOW LONG DOES THE TRIP TAKE BY CAR";
40 INPUT A
45 LET V=D*T/(C-T)
50 LET E=INT(ABS((V-A)*100/A)+.5)
55 IF E>5 THEN 70
60 PRINT "GOOD!  ANSWER WITHIN"E"PERCENT."
65 GO TO 80
70 PRINT "SORRY.  YOU WERE OFF BY"E"PERCENT."
80 PRINT "CORRECT ANSWER IS"V"HOURS."
99 END

READY
```

```
RUN

A CAR TRAVELING 64 MPH CAN MAKE A CERTAIN TRIP IN
 12 HOURS LESS THAN A TRAIN TRAVELING AT 21 MPH.
HOW LONG DOES THE TRIP TAKE BY CAR? 6
GOOD!  ANSWER WITHIN 2 PERCENT.
CORRECT ANSWER IS 5.860465 HOURS.


READY

RUN

A CAR TRAVELING 53 MPH CAN MAKE A CERTAIN TRIP IN
 7 HOURS LESS THAN A TRAIN TRAVELING AT 23 MPH.
HOW LONG DOES THE TRIP TAKE BY CAR? 5
SORRY.  YOU WERE OFF BY 7 PERCENT.
CORRECT ANSWER IS 5.366667 HOURS.


READY

RUN

A CAR TRAVELING 43 MPH CAN MAKE A CERTAIN TRIP IN
 19 HOURS LESS THAN A TRAIN TRAVELING AT 27 MPH.
HOW LONG DOES THE TRIP TAKE BY CAR? 32
GOOD!  ANSWER WITHIN 0 PERCENT.
CORRECT ANSWER IS 32.0625 HOURS.


READY

RUN

A CAR TRAVELING 45 MPH CAN MAKE A CERTAIN TRIP IN
 7 HOURS LESS THAN A TRAIN TRAVELING AT 22 MPH.
HOW LONG DOES THE TRIP TAKE BY CAR? 7
GOOD!  ANSWER WITHIN 4 PERCENT.
CORRECT ANSWER IS 6.695652 HOURS.


READY
```

EDUCATIONAL BENEFIT: An effective use of this type of problem is to assign one problem from a list of several different problems to each student or to small groups of students. After the programs are written, students are directed to check programs written by others. In this way, each student not only fully understands the type of problem assigned to him, but he also gets practice in solving all of the other types as well. Note that the student must solve the problem in general in order to write his program. This should give him more valuable experience than solving two or three similar problems with specific numeric values.

DIGITAL EQUIPMENT CORPORATION

education

AREA: Plotting NUMBER: NAME: DIAMON
SOURCE: Digital Equipment Corp. LANGUAGE: BASIC

DESCRIPTION: This program prints an N by N matrix of diamond shapes, each one being R (odd number input) characters wide.

```
 3 PRINT "FOR A PRETTY DIAMOND PATTERN, "
 4 PRINT "TYPE IN AN ODD NUMBER BETWEEN 4 AND 32."
 5 INPUT R
 6 LET Q=INT(60/R)
 8 FOR L=1 TO Q
11 LET X=1
12 LET Y=R
13 LET Z=2
20 FOR N=X TO Y STEP Z
25 PRINT TAB((R-N)/2);
28 FOR M=1 TO Q
29 LET C=1
30 FOR A= 1 TO N
32 IF C=1 THEN 40
33 IF C=2 THEN 42
34 IF C=3 THEN 44
35 PRINT "!";
37 GOTO 50
40 PRINT "D";
41 GOTO 47
42 PRINT "E";
43 GO TO 47
44 PRINT "C";
47 LET C=C+1
50 NEXT A
53 IF M=Q THEN 60
55 PRINT TAB(R*M+(R-N)/2);
56 NEXT M
60 PRINT
70 NEXT N
83 IF X<>1 THEN 95
85 LET X=R-2
86 LET Y=1
87 LET Z=-2
90 GOTO 20
95 NEXT L
99 END
```

```
FOR A PRETTY DIAMOND PATTERN,
TYPE IN AN ODD NUMBER BETWEEN 4 AND 32.
? 15
```

DIGITAL EQUIPMENT CORPORATION

education

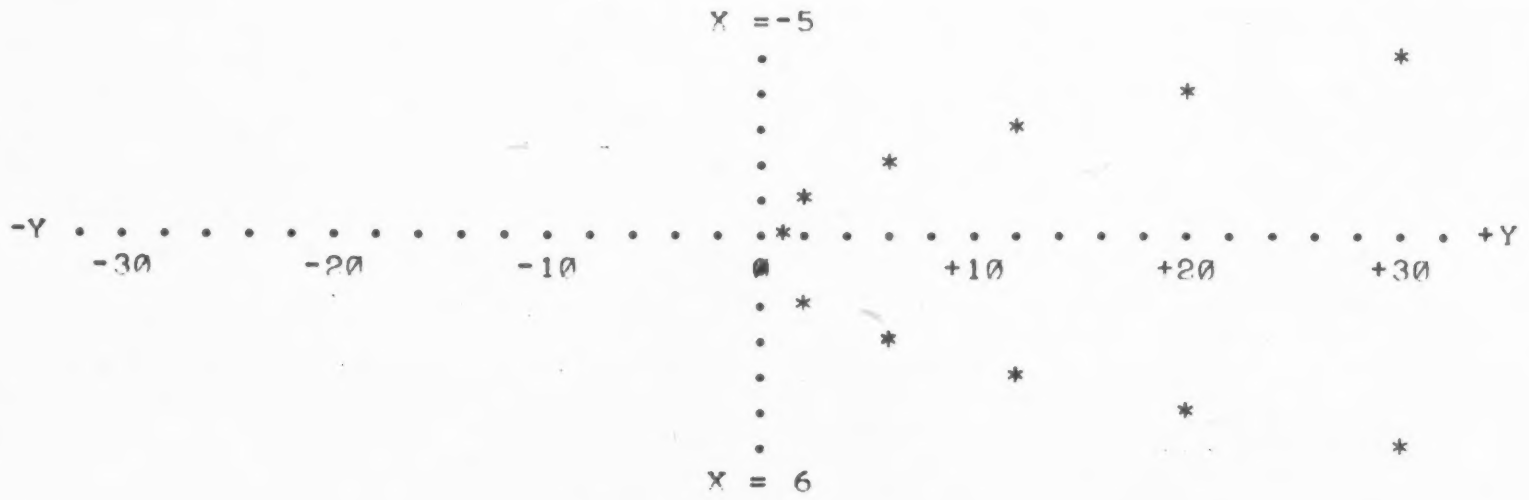
AREA: Plotting NUMBER: NAME: PLOTFN
SOURCE: Digital Equipment Corp. LANGUAGE: BASIC

DESCRIPTION: This program accepts any input function, f(x), at the time of program execution and plots that function from X_{min} to X_{max} in steps of S. The program also inserts the y axis, if it is crossed. Functions which can be plotted range from very simple to rather complex. All of the following are plottable functions:

Function	X Limits		Increment
f(x) = 2 * x	-15	+15	1
f(x) = 30*SIN(x)	-5	+5	.25
f(x) = x-x↑2	-5	+6	.5
f(x) = 30*SIN(.5*x)*EXP(-.2*ABS(x))	0	+15	.25

The program is on the reverse. A sample plot is shown below:

```
WHAT ARE THE INITIAL AND FINAL VALUES OF X, AND THE
INCREMENT SIZE? -5,6,1
```



```
110 PRINT "TO PLOT Y=F(X), THE USER MUST TYPE:"
120 PRINT
130 PRINT "100 GOTO 200"
140 PRINT "200 DEF FNA(X)=(THE EXPRESSION FOR F(X))"
150 PRINT "RUN"
160 PRINT
190 STOP
200 DEF FNA(X)=2*X
210 PRINT
220 PRINT "WHAT ARE THE INITIAL AND FINAL VALUES OF X, AND THE"
 230 PRINT "INCREMENT SIZE";
240 INPUT X1, X2, S
250 PRINT
260 PRINT
270 PRINT TAB(33); "X ="; X1
280 FOR X=X1 TO X2 STEP S
290 IF ABS(X)<.000001 THEN 362
340 LET Y = FNA(X) + 35
350 IF Y>35 THEN 380
360 PRINT TAB(Y);"*";TAB(35);"."
361 GO TO 390
362 PRINT "-Y . . . . . .";
363 PRINT " . . . . . +Y";TAB(FNA(X)+35);"*"
364 PRINT TAB(4);"-30";TAB(14);"-20";TAB(24);"-10";TAB(35);"0";
 365 PRINT TAB(44);"+10";TAB(54);"+20";TAB(64);"+30";
370 GOTO 390
380 PRINT TAB(35);".";TAB(Y);"*"
390 NEXT X
400 PRINT TAB(33);"X =";X2
410 PRINT
440 END

READY

RUN

TO PLOT Y=F(X), THE USER MUST TYPE:

100 GOTO 200
200 DEF FNA(X)=(THE EXPRESSION FOR F(X))
RUN


READY

100 GOTO 200
200 DEF FNA(X)=X↑2-X
RUN


WHAT ARE THE INITIAL AND FINAL VALUES OF X, AND THE
INCREMENT SIZE? -5,6,1
```

(See Plot on Front of Page)

DIGITAL EQUIPMENT CORPORATION

education

AREA: Plotting NUMBER: NAME: SINEX
SOURCE: Digital Equipment Corp. LANGUAGE: BASIC

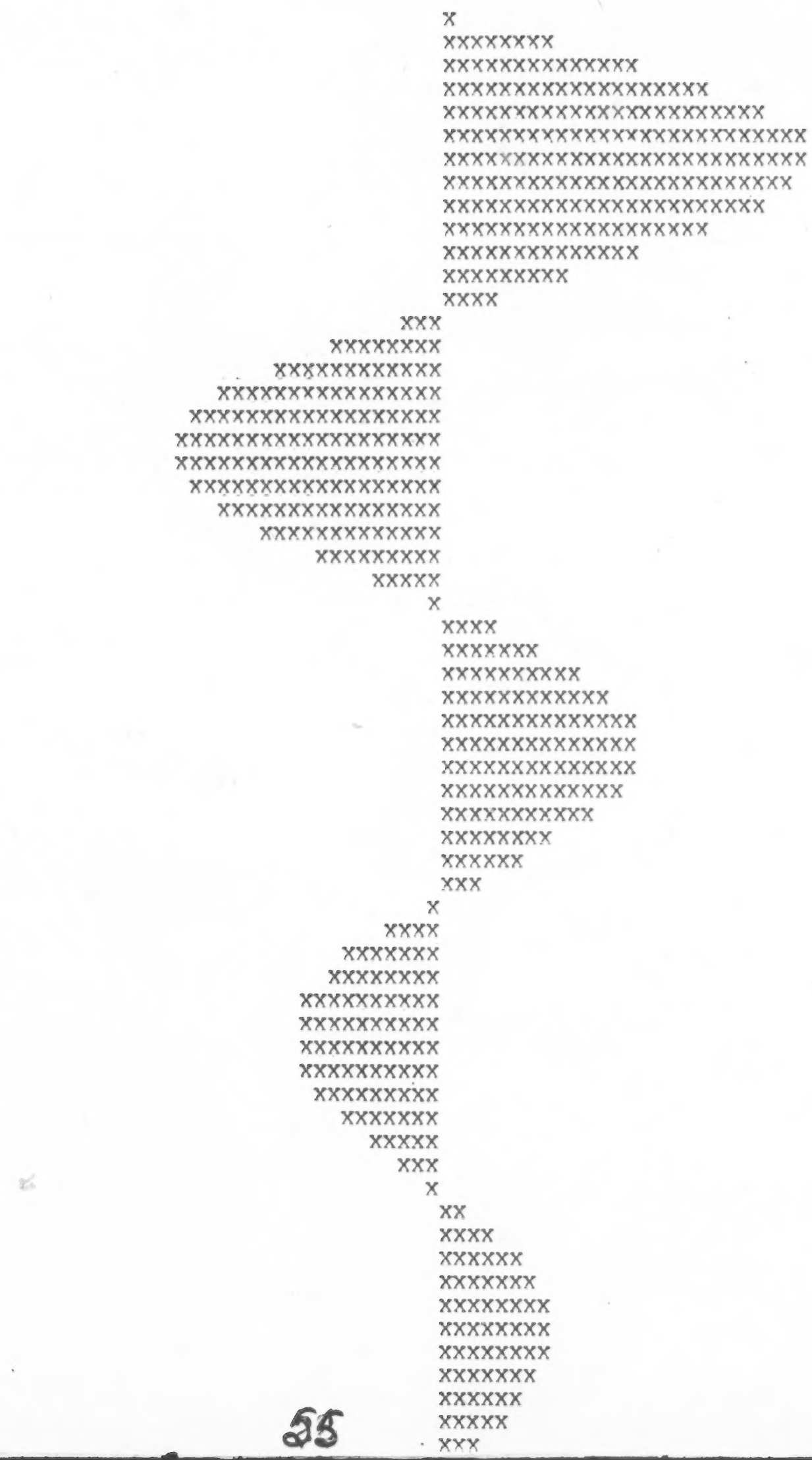
DESCRIPTION: The computer can be used to plot virtually any function. This particular method takes advantage of the TAB command, although it need not. For example, a program to plot a sine wave without using TAB, would be as follows:

```
 1 FOR X=0 TO 19 STEP .25
 2 LET Q=30+30*SIN(X)
 3 FOR B=1 TO Q
 4 PRINT " ";
 5 NEXT B
 6 PRINT "X"
 7 NEXT X
 9 END
```

In the next program, we have filled in the area between the y axis and the curve and we have used the TAB command to replace steps 3 to 5 above.

```
31 FOR X=0 TO 19 STEP .25
32 LET Q=30*SIN(X)*EXP(-.1*X)
33 IF Q>=0 THEN 35
34 GO TO 42
35 PRINT TAB(30);
36 FOR Y=0 TO Q
37 PRINT "X";
38 NEXT Y
40 PRINT
41 GO TO 50
42 PRINT TAB(30+Q);
43 FOR Y=0 TO Q STEP -1
44 PRINT "X";
45 NEXT Y
46 PRINT
50 NEXT X
99 END
```

RUN



DIGITAL EQUIPMENT CORPORATION

education

AREA: Plotting NUMBER: NAME: 3DPLOT
SOURCE: Digital Equipment Corp. LANGUAGE: BASIC

DESCRIPTION: 3DPLOT will plot a three dimensional, perspective graph of a function of three variables. It plots Z (the vertical axis) as a function of X and Y, where X and Y are inside a circle of radius 30.

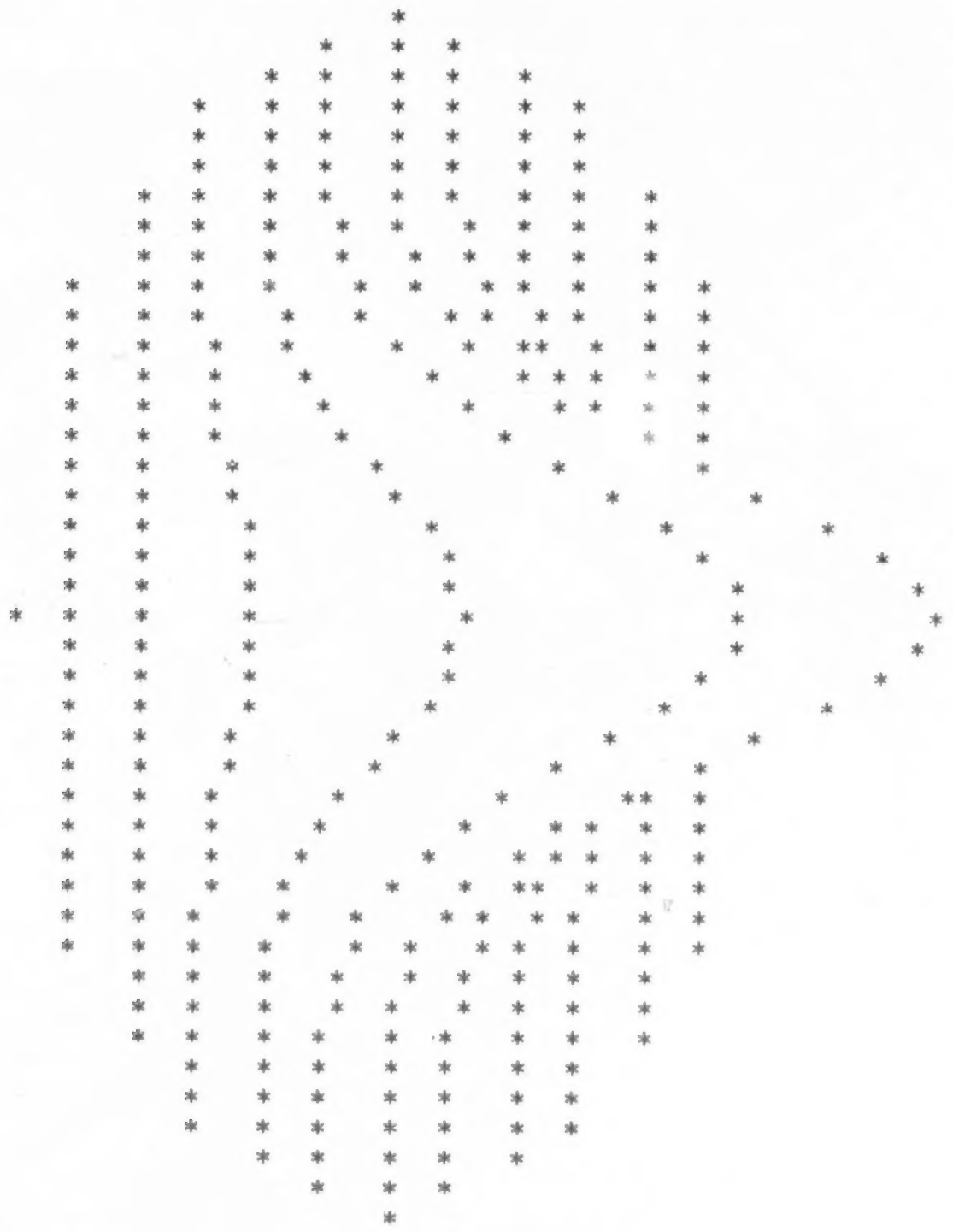
USAGE: Enter the function to be plotted as a DEF FNA(Z) statement in line 5. Then type RUN. The resulting plot will go sideways on the page.

```
  5 DEF FNA(Z)=SQR(900.01-Z*Z)*.9-2
 40 PRINT
 45 LET I1=1
 50 FOR X=-30 TO 30 STEP 1.5
 60 LET L1=-1
 70 LET Y1=5*INT(SQR(900.01-X*X)/5)
 80 FOR Y=Y1 TO -Y1 STEP -5
 90 LET Z=INT(25+FNA(SQR(X*X+Y*Y))-.7*Y)
100 IF L1=-1 THEN 140
110 IF Z>L1 THEN 180
120 IF Z<L2 THEN 150
130 GO TO 200
140 LET L1=Z
150 LET L2=Z
160 IF Z=I1-1 THEN 166
161 FOR I=I1 TO Z
162 PRINT " ";
164 NEXT I
166 PRINT "*";
167 LET I1=Z+2
170 GO TO 200
180 LET L1=Z
190 GO TO 160
200 NEXT Y
210 PRINT
215 LET I1=1
220 NEXT X
230 PRINT
240 END

READY
```

Like all plotting programs, some functions come out "prettier" than others. Two that are known to work are:

```
5 DEF FNA(Z) = 30*EXP(-Z*Z/100)

5 DEF FNA(Z) = SQR (9ØØ.Ø1-Z*Z)*.9 -2
```

```
5 DEF FNA(Z)=30*EXP(-Z*Z/100)

RUN
```



```
READY
```

EDUCATIONAL BENEFITS: Using the computer to plot is an excellent way to teach coordinate geometry. It really shows the interrelation of geometry and algebra as described by Descartes.